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Examining the Statistical Process Experiences of 8th Grade Students *

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Abstract

This study aims at making 8th grade students go through a statistical process and gain experience in this matter and revealing their behaviors, experiences, and difficulties at each stage of this process. Activities were designed in a way allowing the students to experience a statistical process. Then the students were made to get involved in these activities through group work. Data were collected via statistical process activities, the reflection papers of the students concerning the process, and the video-recordings of classroom discussions. The activities were prepared based on Ben-Zvi and Arcavi (2001) as well as expert opinions. The students posed questions that could be directly answered by the help of relevant texts rather than problems that could be solved through data analysis. The groups formed their tables and charts by focusing on just one feature or variable though the data in the activities involved features of more than one variable. As making an inference by interpreting data requires experience, it is recommended in this study that activities be prepared in a way allowing the use of skills of this sort.

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Real-life data

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Introduction

Numeric data are frequently used to make many daily life situations or events striking or persuasive. These numeric data which surround our lives play an important part in making inferences, critical evaluations, and decisions. Producing meaningful results based on data is directly related to how they are interpreted. At this point, the science of statistics, which allows making sense of data and interpreting what is perceived, is needed. The need for interpreting data and making inferences from them makes its presence felt in many fields. Various efforts are made to ensure more common and effective use of data. This need manifests itself in the field of education, too. Thus, statistics education attracts more and more attention (Gal, 2000; GAISE, 2005). In many countries, the statistics has been generalized in mathematics curricula and become important for scientific research. Its benefit in daily life and emphasis on its teaching increase its importance. Guidelines for Assessment and Instruction in Statistics Education (GAISE) (2005) report highlights that our lives are surrounded by numeric data, and every individual needs to have enough statistical knowledge to cope with the situations they encounter in their lives and to have a more peaceful, happier, and more productive life. The report features the importance of statistics by stressing that being statistically qualified and statistically literate plays an important role in the daily and professional lives of individuals. According to Gal (2000), it is not surprising that interest in the statistics has been increasing for around ten years, and research on

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science and mathematics education attempts to improve the numerical skills and statistical literacy levels of individuals. Increase in the importance attached to statistics and rise in the emphasis laid on the necessity of statistics education show that it is a field worth studying. Every individual in the society is expected to be statistically qualified, have a meaningful approach to what takes place in their lives, and be capable of interpreting what they experience (GAISE, 2005). Surely, individuals can have these expected skills only if they are statistically literate enough.

The statistics education literature contains various approaches to and definitions of statistical literacy. Wallman (1993) describes statistical literacy as being able to understand the statistical results surrounding the daily life, making a critical evaluation of them, and reasoning for making decisions in private life and daily life. Statistical literacy involves knowing what basic statistical concepts mean, using statistical concepts and methods, applying statistical symbols properly, recognizing and interpreting the different representations of data, and so on (Garfield, 1999; Rumsey, 2002; Snell, 1999). There is a consensus on two skills that form the basis of statistical literacy (Gal, 2004; Rumsey, 2002). The first one is the capability of students to actively use the statistical information they encounter in their daily lives, to make a comprehensive analysis and interpretation of such information, and to evaluate relevant results. The second one is the ability of students to make sense of statistical terms, concepts, and approaches, which allow them to comprehend data, and to identify the relationships between concepts. It is not enough that students read and interpret statistical data and messages. They must also discuss on them, associate them with one another, and explain the results clearly.

Based on the information given above, statistical literacy can be defined as the skill of making sense of the situations encountered, making inferences about them, and interpreting and presenting the obtained results. This is an important resource we can use any time in our lives. Thus, it is very important that students have adequate statistical literacy, are statistically qualified, and gain meaningful experiences. Statistical literacy obliges us to improve our ability to correctly understand, interpret, and evaluate the statistical information surrounding our daily lives (Koparan, 2012: 3). In a sense, this ability comes into existence while an individual is making a decision over a situation by following particular steps. Indeed, there must be a process involving particular steps, and certain behaviors need to be displayed in this process for individuals to be called statistically literate. Reports on mathematics education put an emphasis on those behaviors and skills related to the field of statistics which are expected from students. GAISE (2005) lists the expectations of NCTM (2000) from students in statistics education from primary education until the end of secondary education as follows:

1. Posing problems and collecting, organizing, and representing data to solve these problems;
2. Selecting appropriate statistical methods to analyze data;
3. Making predictions and inferences about data and evaluating and improving them.

The expectations of NCTM (2000) in statistics education show that primary education and secondary education students are anticipated to actively participate in statistical research, pose problems, collect, organize, and analyze data, interpret data, and so on. Indeed, these steps refer to a problem-solving activity which can be called statistical process.

Statistical Process

While individuals are working on any problem in their daily lives, they mostly do statistics unawares. This process starts with specifying a problem, continues with collecting and organizing the data needed to solve the problem and presenting such data with appropriate representations, and ends with interpreting and associating such data. The structure consisting of such successive steps is called *statistical process*. Firstly introduced by Tukey (1977), statistical process involves specifying, organizing, representing, and analyzing data (Ben-Zvi, 2004). To Cobb and Moore (1997), statistical process aims to make sense out of data as if an unknown place was being discovered. Statistical process consists of such stages as *specifying a problem and formulating hypotheses*, *collecting and analyzing data*, *interpreting and associating results* (Graham, 1987). Konold and Higgins (2003) emphasize that this is not only a linear process, and there may be some forward and backward transitions. GAISE (2005) report defines statistical process as a four-stage one. The first one includes understanding and posing problems to be solved by using data. The second one involves collecting and organizing data properly. The third one is the stage in which data are analyzed by use of graphical representations and numeric arrangements. The final stage contains the interpretation of analyses, establishing relationships between the problem and analyses, and presenting results. Watson (2006) developed a model for statistical literacy and used such stages as data collection, data representation, data reduction, and inference. These stages point to a statistical process. Just like every research requires following particular stages by its very nature, working on statistical data requires following specific steps, too. That shows that a process of this sort may gain a place in the field of statistics. Accordingly, a statistical process (a four-stage one) was taken as basis in the present study. These four stages are *specifying a problem and formulating hypotheses*, *collecting data*, *analyzing data*, and *interpreting data*.

Research in the field of statistics has started to focus on statistical process, too. Ben-Zvi (2004) carried out two case studies in order to observe the steps followed by the 7th to 9th grade students in statistical process and their reasoning on these steps. To this end, he designed activities for students and made them go through a statistical process through these activities. In the first case study, hypotheses were provided in a specified context without any data presentation, and students were asked to express their opinions on them. After their opinions about the hypotheses were received, actual data related to the context were presented. The students were expected to work on these data. After they worked on the data, they were asked what measures of central tendency and dispersion were the best to use in summarizing the data and what the best way of representing the data was. In addition, the students were asked to discuss the results they obtained by communicating with one another and using the technology. This case study indicated that the students mostly had a tendency to understand the complex situations related to the context and to make decisions on such situations. However, in the questions regarding the change of scaling between units on the chart axes, the students only gave answers focusing on the displacement of the values on axes. In the second case study, the students were asked to express their opinions within the context provided and discuss different opinions. They were expected to check the validity of the opinions they defended by means of computer and decide on appropriate representations. Then they were requested to offer solutions to the problem within the context. In this second case study, the students were provided with a platform for discussion. In this way, they had a chance to evaluate different opinions and their peers through presenting the opinions they defended by use of different representations. In the end, it was recommended to create suitable environments where classroom discussions can be made and experiences concerning real life situations can be undergone under teacher's guidance and to help students do statistical reasoning and improve their reasoning skills. In addition, it was highlighted that curricula should contain practices involving statistical processes of this sort. Indeed, that indicates that making students go through statistical processes may create awareness among students regarding different representations and data. Short and Pigeon (1998) carried out a study on undergraduates, postgraduates, and pre-service teachers and requested the participants to specify in detail the research steps that they would follow before a research project. The participants were expected to properly report what sort of a plan they made for their research designs. That points to a statistical process involving stages such as specifying a problem,

collecting data, analyzing data, and interpreting results. The study concluded that the research projects developed by the students helped them acquire statistical knowledge and gain experience in statistics. In addition, the study reported that such knowledge and experiences enabled the students to make sense of the statistical situations they encountered. Biehler and Steinbring (1991) conducted a study on primary education second level students. In that study, the research process was introduced as an *investigator's job*. In the study, the teachers assigned tasks called "toolkit" consisting of concepts and graphical representations to the students step by step. The dataset was obtained in this way. The study reported that use of open-ended problem situations in the process makes learning and teaching harder.

The Aim and Significance of the Study

It is emphasized that improving such skills of students as using and interpreting statistics properly and making predictions and decisions based on data should be one of the objectives of mathematics education so that students are conscious citizens and consumers (MEB, 2009). Garfield and Ben-Zvi (2008) argue that one of the important elements of the statistics course is focusing on the nature of data, and it is crucial to know where data come from, how good data are produced and collected, and what kind of analysis and decision-making methods should be used for the collected data. They say that meaningful and rich datasets are needed to accomplish that. Accordingly, it is worth investigating what sort of a process students follow when they encounter a statistical problem because the only concern is not students' finding correct answers by solving certain statistical problems. Research in the field of statistics is just at the start, and there is no study dealing with the experiences of students within statistical process in Turkey. As a result, the profile of students concerning this field is not known. That brings to mind the question of whether students are cultivated by the current system of education as stated above. In the primary education mathematics curriculum, statistics is taught on the basis of different topics in each different grade. The curriculum involves each one of the statistical process stages. However, these stages are taught in different grades. The 6th grade students acquire the skills of *posing research problems regarding a given situation*, *choosing an appropriate sample*, *collecting data concerning the problem specified*, *presenting the data in appropriate statistical representations and interpreting them*, *noticing the misinterpretations that may occur in the use of column charts*, *making calculations regarding the arithmetic mean and the range of the data*, *interpreting the data*, and *making predictions about the data*. The 7th grade students acquire the skills of *forming column and line charts based on more than one criterion*, *interpreting them*, *forming pie charts*, *forming views for real life situations through creating statistical representations*, *making predictions based on the data*, *making calculations including the median, mode, and interquartile range of the data*, and *interpreting*. The 8th grade students, on the other hand, acquire the skills of *forming and interpreting histograms*, *making standard deviation calculations*, *and forming views for real life situations by use of measures of central tendency and standard deviation* (MEB, 2009). Statistical process can be achieved only if its stages are taught as a whole. Thus, offering different stages in different grades can be considered an important shortcoming in terms of the accomplishment of the goals of statistics education. This being the case, the present study aims at making primary education 8th grade students go through a statistical process and gain experience in this matter and revealing their behaviors, experiences, and difficulties at each stage.

Method

Research Design

Firstly, activities representing the statistical process which the students would go through as planned were designed in the present study that aimed to depict the experiences of the students in the learning environment designed for making them go through a statistical process as well as the difficulties they had during their experiences. With these activities, an attempt was made to enable the students to experience the stages of statistical process and work on actual data. The prepared activities were implemented through group work. The teacher's opinions were received in forming the groups. The activities were conducted at two stages. At the first stage, the groups were provided with general information and requested to complete the first part of the activities. The first part of the activities was completed in one course hour. At the second stage, the groups were allotted 2 weeks to do research about the second part of the activities, report what they found, and get prepared for presenting them in the next gathering. After the activities were completed, the data were interactively analyzed as a whole by use of different data collection tools.

Participants

The research participants consisted of 22 8th grade students from a primary school with moderate success located in Trabzon. A heterogeneous class was selected to determine the statistical process experiences of the student groups. In other words, the selected class contained students with a high level of success, students with moderate success, and students with a low level of success. In determining the success level of the class, the teacher's views and the placement test (PT) scores from the previous years were taken into consideration. In the primary education mathematics course, subjects related to probability and statistics are taught to the 8th grade students in a spiral structure. In the 6th grade, students learn subjects such as *posing questions for research*, *tables and charts*, and *measures of central tendency and dispersion*. In the 7th and the 8th grades, on the other hand, they learn subjects such as *tables and charts* and *measures of central tendency and dispersion* (MEB, 2009). That is, students learn certain knowledge and skills related to statistics in different grades. The primary education 8th grade students were included in the present study because it was assumed that they had more knowledge of statistics.

Data Collection Tools

Data were collected via statistical process activities, the reflection papers of the students concerning the process, and the video-recordings of classroom discussions. The reflection papers were used so that the students' statistical process experiences could be handled within a broader framework. In the reflection papers, the students were requested to summarize their research processes by mentioning the difficulties they experienced and the contributions of the research they did for the activities. The video-recordings were used for analyzing the presentations about the activities and the groups' views about the works of one another in more detail.

The statistical process activities were prepared based on Ben-Zvi and Arcavi (2001) and the opinions of a faculty member conducting research in the field of statistics education. The suitability of the statistical process activities for the class level was asked to the mathematics teacher of the students. Based on the teacher's response, necessary adjustments were made on the activities. In this way, they were finalized. Statistical process stages such as specifying a problem and formulating hypotheses, collecting data, analyzing data, and interpreting data were taken into account in preparing the activities of *The Transportation Choices of the Tourists Coming to Turkey*, *Export in Our Country*, *Newborn Babies*, and *Calorie at Any Moment of Our Life*.

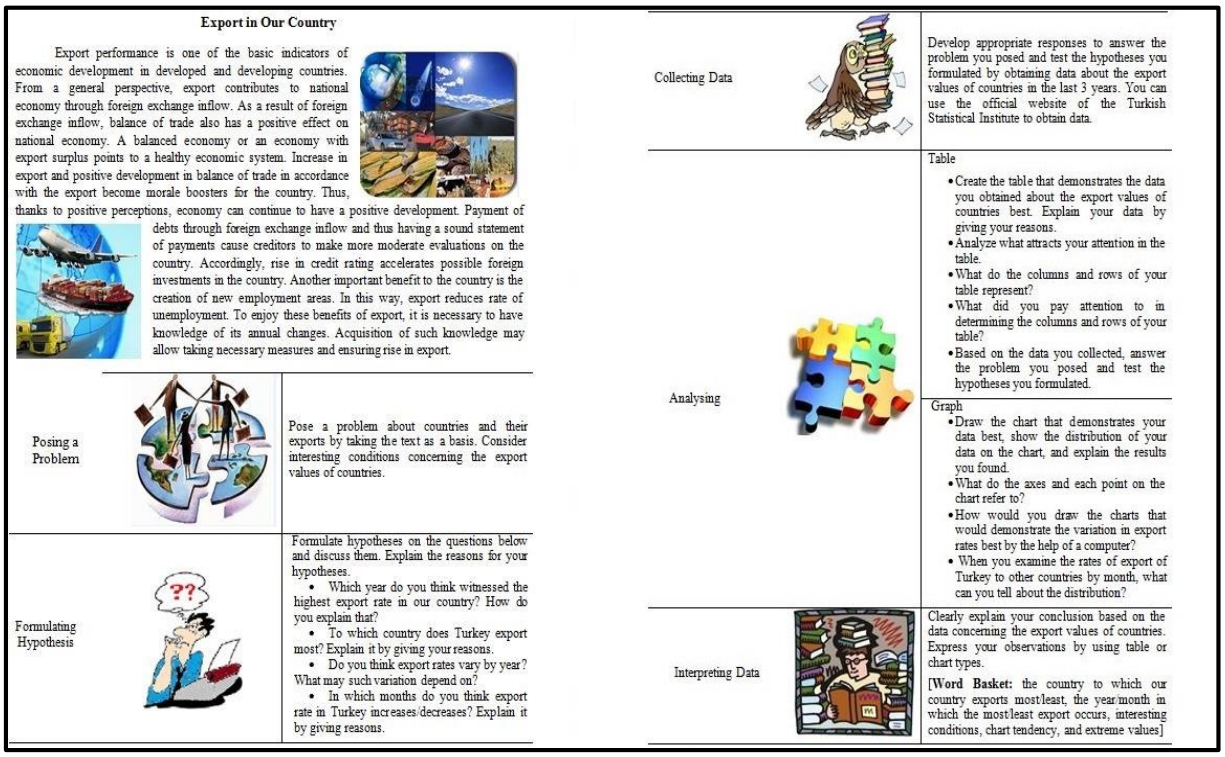
At the stage of *specifying a problem and formulating hypotheses*, the students were asked to specify problems worth researching in relation to the texts provided and formulate hypotheses about these problems. The stage of *collecting data* was the stage where the students would obtain data that would allow them to solve the problems specified at the first stage and test the hypotheses formulated. At this stage, the students were expected to collect actual data in regard to the texts included in the activities. It was aimed for the students to obtain the data at first hand. They were guided about how they could

obtain the data. *At the stage of analyzing data*, the students were asked to draw tables allowing them to comprehensively show the data they collected. It was aimed for the students to make decisions on the variables included in their tables based on their own opinions and the data they collected. For example, to make it easier for the students to formulate hypotheses about the activity of Export in Our Country, questions such as *Which year do you think witnessed the highest export rate in our country?*, *To which country does Turkey export most?*, and so on were asked to them. In this way, it was made sure that the students formulated appropriate assumptions and did not deviate from the aim of the research much. Sub-problems were addressed to the students for them to introduce the tables they would draw. At this stage, besides the tables, the students were also asked to draw the charts that would demonstrate their data best. Apart from that, they were expected to draw charts in regard to the sub-problems addressed. Moreover, the students were requested to test the hypotheses they formulated in regard to the problems and express the results they obtained. At the stage of *interpreting data*, the students were expected to express, interpret, and discuss the results they obtained through analyses. What's more, a Word Basket was offered to the students to help them express their observations and opinions regarding the process. In other words, they were asked to summarize and interpret the research results by the help of keywords given as clue such as *the country to which our country exports most/least*, *the year/month in which the most/least export occurs*, *interesting conditions*, *chart tendency*, and *extreme values*. Table 1 presents the activities prepared in accordance with the research aim and the contents of such activities.

Table 1. The Prepared Activities and Their Contents

Activity	Content
The Transportation Choices of the Tourists Coming to Turkey	It deals with the tourists who want to discover the beauties of our country and see different places and their transportation choices.
Export in Our Country	It deals with the importance of export, which is the basic indicator of economic development of a country, and export in our country.
Newborn Babies	It deals with obtaining such information about newborn babies as weight and height.
Calorie at Any Moment of Our Life	It deals with different food types, the calorie amounts the foods contain, and the effects of calorie amounts on our health.

The general structure of one of the activities prepared by taking into consideration the statistical process stages is given below.



Export in Our Country

Export performance is one of the basic indicators of economic development in developed and developing countries. From a general perspective, export contributes to national economy through foreign exchange inflow. As a result of foreign exchange inflow, balance of trade also has a positive effect on national economy. A balanced economy or an economy with export surplus points to a healthy economic system. Increase in export and positive development in balance of trade in accordance with the export become morale boosters for the country. Thus, thanks to positive perceptions, economy can continue to have a positive development. Payment of debts through foreign exchange inflow and thus having a sound statement of payments cause creditors to make more moderate evaluations on the country. Accordingly, rise in credit rating accelerates possible foreign investments in the country. Another important benefit to the country is the creation of new employment areas. In this way, export reduces rate of unemployment. To enjoy these benefits of export, it is necessary to have knowledge of its annual changes. Acquisition of such knowledge may allow taking necessary measures and ensuring rise in export.

Posing a Problem		Pose a problem about countries and their exports by taking the text as a basis. Consider interesting conditions concerning the export values of countries.
Formulating Hypothesis		Formulate hypotheses on the questions below and discuss them. Explain the reasons for your hypotheses. • Which year do you think witnessed the highest export rate in our country? How do you explain that? • To which country does Turkey export most? Explain it by giving your reasons. • Do you think export rates vary by year? What may such variation depend on? • In which months do you think export rate in Turkey increases/decreases? Explain it by giving reasons.
Collecting Data		Develop appropriate responses to answer the problem you posed and test the hypotheses you formulated by obtaining data about the export values of countries in the last 3 years. You can use the official website of the Turkish Statistical Institute to obtain data.
Analysing		Table • Create the table that demonstrates the data you obtained about the export values of countries best. Explain your data by giving your reasons. • Analyze what attracts your attention in the table. • What do the columns and rows of your table represent? • What did you pay attention to in determining the columns and rows of your table? • Based on the data you collected, answer the problem you posed and test the hypotheses you formulated. Graph • Draw the chart that demonstrates your data best, show the distribution of your data on the chart, and explain the results you found. • What do the axes and each point on the chart refer to? • How would you draw the charts that would demonstrate the variation in export rates best by the help of a computer? • When you examine the rates of export of Turkey to other countries by month, what can you tell about the distribution?
Interpreting Data		Clearly explain your conclusion based on the data concerning the export values of countries. Express your observations by using table or chart types. [**Word Basket:** the country to which our country exports most/least, the year/month in which the most/least export occurs, interesting conditions, chart tendency, and extreme values]

Conducting the Activities

The activities were conducted through group work. The groups were made to have a heterogonous structure. It was considered that there could be more interaction among students with a low level of success, the students with moderate success, and the students with a high level of success. By very nature of the statistical process forming the basis of the study, the individuals were expected to specify a problem in regard to the text provided, collect data, analyze them, and interpret them based on the results of such analyses. Individual work in this matter may result in more limited products. In addition, it was thought that group work could make the activities addressed in a broader framework by enabling the students to interact. Before the activities started, the groups were formed based on the teacher's views. Five groups were formed. Of these groups, two groups consisted of five students, and three groups consisted of four students. Necessary information was given to the students before the activities started in order to ensure their active participation. Since there were five groups, one activity was chosen randomly (i.e. *Calorie at Any Moment of Our life*) and assigned to two groups. The activities were distributed to the groups randomly. They were carried out at two stages. The first stage involved only specifying a problem and formulating hypotheses. At this stage, the students were asked to pose a problem appropriate to the text in the activity and formulate hypotheses accordingly. The problems posed and the hypotheses formulated by the groups at this stage were just the products of their imaginations and comments. The works of the students were given back after taking one copy of their answers concerning the problems they specified and the hypotheses they formulated in relation to their problems by using the questions we asked to help them formulate hypotheses on relevant subjects in the activities. At the second stage, it was decided to distribute the works produced at the first stage to the groups for them to check their answers and hypotheses by use of actual data. The groups were allotted two weeks between the first stage and the second stage so that the students could have long time to study comfortably, and sounder data could be obtained. The groups were requested to present the reports they prepared about the activities in the classroom environment at the end of two weeks. A classroom discussion was organized for the students to share their experiences and acquisitions in the process with one another and interact with one another more and to reveal their reflective thoughts regarding the process. The classroom discussion was video-recorded in order to reveal the missing

points about the behaviors and situations of the students regarding the process. In the end, reflection papers were collected from all students. By the way, in the beginning, explanations were made about the points that were unclear to the students. However, such explanations aimed to make the expressions clearer rather than providing guidance. At the second stage, no intervention was made in the presentations or the responses of the students.

Data Analysis

The answers given by the students at the stages of specifying a problem and formulating hypotheses, collecting data, analyzing data, and interpreting data were evaluated separately. The separate evaluation of these stages allowed having in-depth knowledge of the experiences of the students at different statistical process stages. A data repository was formed about each statistical process stage by use of the data obtained from the groups. The formed data repositories were examined, and deficiencies, wrong thoughts, and appropriate/inappropriate expressions regarding each stage were determined based on the consensus of the two researchers. Expert opinions were received when there was no consensus. Missing points were compensated by supporting what was determined about the data in the repositories with video-recordings and the students' reflection papers regarding the process.

The qualitative analysis method was used in analyzing the reflection papers. Firstly, the raw data were reduced to make them suitable for primary coding. The reduced reflection papers were coded by two researchers. Common codes were identified, and themes were created about them. These themes were associated with the repository of the related statistical process stage. In this way, conditions concerning each stage were depicted. The video-recordings of the students' presentations and the views they wrote down about their experiences in the statistical process were used to make comments on what they did in this process.

Results

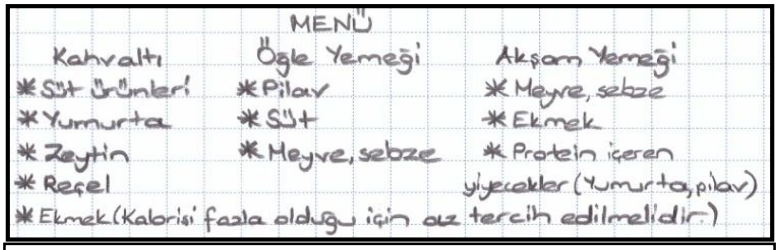
The students were made to go through a statistical process by means of activities associated with real life situations. In this way, the students were able to gain experience in the statistical process stages. This section presents the experiences, difficulties, and behaviors of the students in each statistical process stage separately.

Results Concerning the Stage of Specifying a Problem and Formulating Hypotheses

At this stage, the students mostly posed questions that did not require the use of numeric data and aimed to reveal the contributions or harms of the relevant issues to the society. In other words, they did not pose problems involving obtaining statistical results by the help of numeric data. For example, the group working on export posed problems such as *what sort of a solution can we find for an industrialized country?* and *what does rise in export bring us?* By posing problems of this sort, this group mostly focused on the situations that could be confronted in the society or the problems related to the development of the society. The group working on the amounts of calories in foods posed questions such as *why do the calories in foods make us put on weight?* and *to whom should we apply to put on weight?* In addition, most of the students failed to determine the variables in the context correctly and posed problems that did not require any research. In other words, they remained limited to the problems about which people could express their opinions based on their experiences in their social lives. The group working on newborn babies posed a problem requiring the comparison of twins and non-twins in terms of size even though the context involved baby weight and height. They posed the following problem: *What are the sizes of twins in comparison to non-twins?* In presenting their reasons for their answer to the problem, they said, "*There is no difference between us and the twins around us. We are the same.*" In this way, they demonstrated a situation they encountered in their lives. The group working on the transportation choices of the tourists coming to Turkey posed the following problem: *What sort of a cultural structure do the people coming from different countries have?* With this question, they expressed their curiosity about a situation which they did not have much chance of encountering in their lives. The problem posed by one of the groups working on the amounts of calories in foods posed is as follows: "*Why do foods contain calories?*" Any person can answer this question from his/her own perspective. Therefore, this group was quite far from statistics. It can be said that the students failed to pose a problem in accordance with the context given. They posed a problem not requiring statistical results. They posed a statement which they referred to as problem when they faced the context for the first time. They posed it without collecting any data. After the students proceeded to the stage of collecting data, they tried to pose somewhat different problems. As they collected numeric data regarding the context, they started to pose problems requiring obtaining statistical results. Although the group working on export posed problems about social problems and development when they confronted the context for the first time, they began to pose problems questioning the annual variation of export in our country after they collected data. While one of the groups working on the amounts of calories in foods posed a problem that could be answered based on personal points of view in the beginning, they posed a problem questioning the amounts of calories in different food types later on.

While the groups working on the amounts of calories in foods were successful in formulating hypotheses in relation with the questions addressed to them to help them formulate hypotheses, the group working on the transportation choices of the tourists coming to Turkey did not show the same success. One of the groups working on the amounts of calories in foods formulated the following hypothesis: "*The amounts of calories in foods vary by carbohydrate and fat content. For example, we put on weight when we eat bread because it is a food rich in carbohydrate.*" This hypothesis indicates that the students could evaluate food by group. Although they were provided with the question asking how to find out babies' normal delivery times, weights, and heights, the group working on the newborn babies only focused on weight and formulated the following hypothesis: "*If a baby is over 8 kilos in weight, s/he can be called an ill one. If s/he is not more than 6 kilos, s/he can be called a healthy one.*" In this hypothesis, the students were quite far from the weight range of babies. The group working on export formulated the following hypothesis: "*We had technological advancements in 2010. We have good relations with foreign countries.*" The

students in this group failed to formulate a hypothesis because they gave answers irrelevant to the main topic. In other words, there is a direct relationship between students' familiarity with the context and their hypotheses. The hypotheses of the group concerning the question asking the months in which export increases or decreases in our country and the reasons they mentioned are more remarkable. Their hypothesis and relevant results are as follows: "*Export increases in summer and decreases in winter. This is because; there are more products in summer. There are fewer products in winter because it is cold. People are engaged in agriculture more in summer. Thus, more export occurs in summer.*" The students justified their hypothesis based on their experiences. However, they were limited to only one dimension because they focused only on agricultural products. One of the groups working on the amounts of calories in foods formulated the following hypothesis based on their experiences: "*Carbohydrate or fat we get from food affect calorie amount. Thus, we should prefer food with few calories, that is food with little carbohydrate and fat content so as not to put on weight.*" It is clear that the more relevant the activity context is to the daily lives of students, the more relevant predictions can be used in drawing conclusions. In addition, the groups working on the amounts of calories in foods were requested to prepare a healthy menu for the amount to be met per day and express their reasons for it. One of the groups prepared the following menu by expressing their reasons for it:



MENU

Breakfast	Lunch	Dinner
*Milk products	*Pilaf	*Fruit and vegetables
*Egg	*Milk	*Bread
*Olive	*Fruit and	* Food containing protein
*Jam	vegetable	(egg, pilaf)
*Bread (to be eaten little because it contains many calories)		

Figure 1. The Menu Prepared by a Group Working on the Amounts of Calories in Foods

The group working on the transportation choices of the tourists coming to Turkey justified their hypothesis concerning the annual variation in the number of the tourists visiting our country as follows: "*The number of the tourists coming to our country varies. This is because; they do not go to a place where they have already been.*" In general, the students formulated hypotheses on the basis of the questions provided in the activities. However, they mostly did not make any explanation about what they took as basis in formulating their hypotheses. They were just interested in answering the questions given.

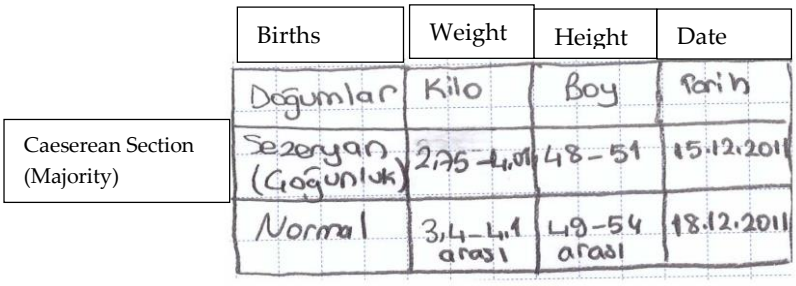
Results Concerning the Stage of Collecting Data

At this stage, the students were asked to collect data in accordance with the texts given in the activities. They collected data about the activity topics from the Turkish Statistical Institute, the Internet, related institutions and organizations, or their friends and relatives. It was thought initially that the students would have the least difficulty at the stage of collecting data. However, this expectation was not fulfilled. Indeed, collection of data is a determining factor for the following stages. In this sense, superficial data collection at this stage caused the groups to work on limited data. Another problem observed at this stage was that one of the groups produced the data by themselves through making predictions or setting random values rather than using actual data. The group working on the transportation choices of the tourists coming to Turkey created their own dataset based on predicted values rather than collecting actual data. They did so although at least one group member had computer and Internet facilities at his/her home. Therefore, it can be said that the students in this group failed at

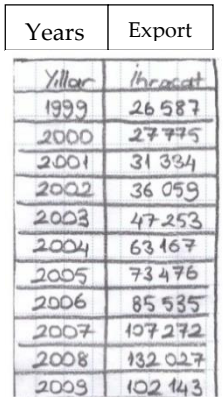
this stage. On the other hand, the groups working on newborn babies and the amounts of calories in foods collected their data in a more comprehensive way. Since they were more familiar with the relevant contexts, they were able to think on what variables they could take as basis in collecting data. The groups working on the amounts of calories in foods were able to collect their data by taking different dimensions as basis because they were more familiar with the concept of calorie in their daily lives.

Results Concerning the Stage of Analyzing Data

At the stage of analyzing data, the students were requested to draw tables and charts representing the data they collected. In addition, attention was paid to whether or not the students were aware of what columns and rows in the tables meant and what horizontal and vertical axes in the rows referred to. It was seen that mostly the students formed tables with a simple structure without classifying the data. For the most part, the tables contained numeric values corresponding to the variables. Only the group working on newborns worked more comprehensively in representing the data on a table. This group tabulated the data concerning the birth weights and heights of babies based on a systematic classification. The other groups created simple tables including the variables and their equivalents in frequency. The table created by the group working on newborn babies and simple tables formed by one of the other groups are given below:



The group presenting the data categorically

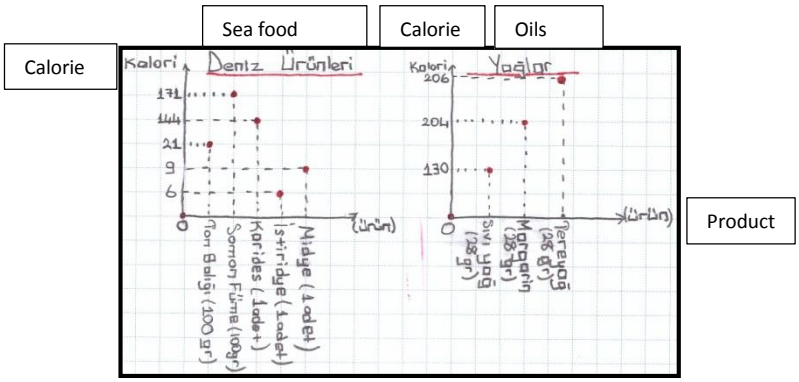


The group preparing a simple table

Figure 2. Examples from the Table Drawings of the Groups

The groups failed to cover all variables in their tables and charts. The students mostly focused on just one dimension. They were not able to create a table that contained more than one variable and indicated the numeric values corresponding to such variables. However, they knew what the columns and rows referred to in the tables they drew.

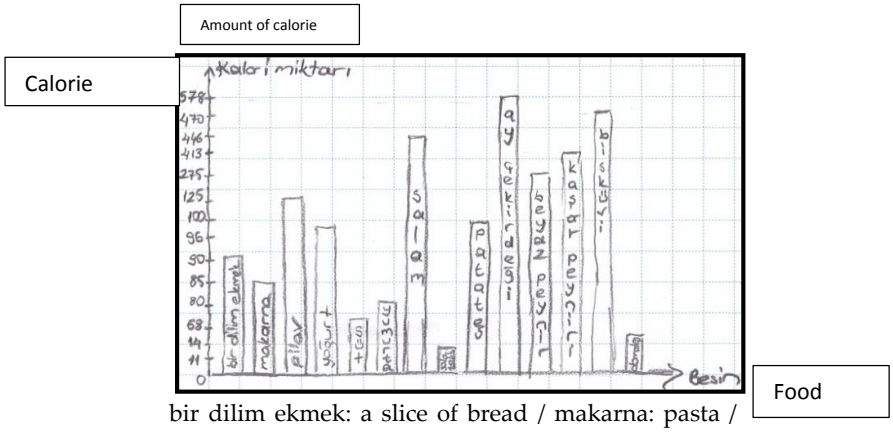
The students mostly presented their data in ordered pairs in the coordinate system. They presented the data by producing ordered pairs consisting of the variables they examined and the numeric values corresponding to them in the charts they drew. The variables were presented in charts in such a way that they did not have values varying within a range, but corresponded to single values. Two charts of this sort drawn by the group working on the amounts of calories in foods are as follows:



*ton balığı: tuna fish / somon fume: smoked salmon / karides: shrimp / istiridye: oyster / midye: mussel / sıvı yağ: oil / margarin: margarine / tereyağ: butter

Figure 3. The Drawings of the Group Working on the Amounts of Calories in Foods

As is seen in the charts above, the students tried to represent their data concerning foods and the amounts of calories in them by classifying them (cereals, meat, milk, sea food, and oils) and drawing separate charts involving ordered pairs for each food group. They preferred to draw separate charts representing the values of a single food group rather than creating a complex chart allowing the representation of all food groups together. They focused on a single dimension by forming separate charts for each food group. In the charts about food groups, they paid attention to calculating the calories of the equal amounts of the foods. They did so to compare the calories of the foods of equal amounts. Although these students took this detail into consideration, they failed to draw a chart allowing representing all food groups together and comparing them. They failed to make any adjustments that would make other aspects clear. The students expressed their reasons for drawing charts of this sort as follow: "*We tried to represent all of them together, but we considered it too complex. So, we wanted to draw cereals, sea products, milk products, and so on separately.*" A group working on the amounts of calories in foods and the group working on the transportation choices of the tourists coming to Turkey used column charts contrary to the other groups. The group working on the transportation choices of the tourists coming to Turkey did not collect data. They used their imaginations in drawing the chart concerning the data they produced based on their predictions. They drew representative column charts. The chart drawn by the other group working on the amounts of calories in foods is as follows:



bir dilim ekmek: a slice of bread / makarna: pasta / pilav: pilaf / yoğurt: yogurt / süt: milk / yumurta: egg / salam: salami / salatalık: cucumber / patates: potato / ay çekirdeği: sunflower seed / beyaz peynir: white cheese / kaşar peyniri: kashar cheese / bisküvi: biscuit

Figure 4. The Chart Drawn by the Other Group Working on the Amounts of Calories in Food

The students drew the chart given above in columns by putting different foods and their calories on the axes. In fact, there is no difference between this group and the other groups that matched the variables and the numeric values corresponding to them. There is only a visual difference. This is because; while the data are represented in points in one chart, the data are represented in columns in the other. Indeed, each one features the numeric data corresponding to each variable. As a result, these charts focus on a single dimension. This group working on the amounts of calories in foods drew the chart by taking certain foods as basis. No explanation was made whether or not the calorie data corresponding to the foods of equal amounts were used. Thus, it was not clear whether or not the appropriate data were used to make comparisons between the foods. On the other hand, they tried to show all the data they collected in regard to foods and their calories and compare the foods by using a column chart. The members of this group expressed the reasons for drawing a chart of this sort as follows: "*We chose a chart of this sort to make it clearer and to demonstrate the data*." The students mostly had knowledge of what horizontal and vertical axes on the charts referred to. However, when the group working on export put the variable of years on the vertical axis and the variable of amount of exports on the horizontal axis, an arrangement where the amounts of exports corresponding to the years were not sorted came out. The chart drawn by the group working on export is as follows:

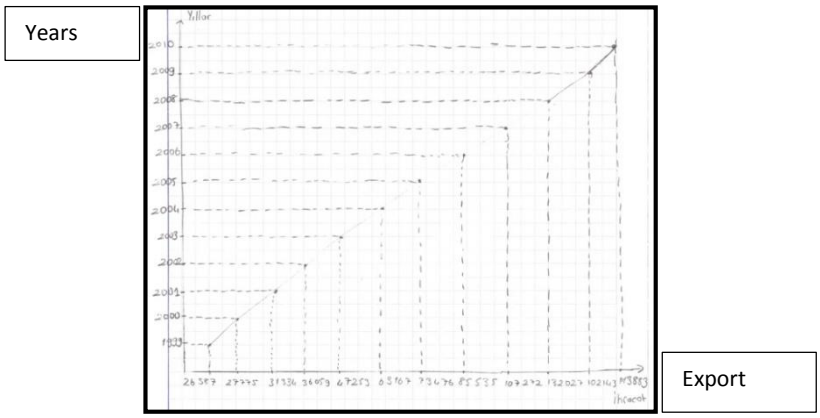


Figure 5. The Chart Drawn by the Group Working on Export

As is seen above, the students put the variable of years on the y axis and the variable of amount of export on the x axis. They had difficulty in putting the data on appropriate axes. The amount of exports was put on the x axis without applying ascending sort. The data were presented by matching the years with the amounts of exports corresponding to them. The chart drawn by the students was not

sufficient to represent the data. In addition, the students ignored the variable of country. Although they were asked to investigate the variation of export values by country, they collected and analyzed data only concerning the amounts of exports in different years. During their presentation, this group expressed their views regarding the chart they drew as follows: "*If we could draw the chart again, we would put the years on the horizontal axis and the amounts of exports on the vertical axis. We did not sort the figures indicating the amounts of exports. Even though we found out that it was 2008 when the biggest amount of exports took place, the chart we drew does not present this detail.*"

Mostly the groups did not answer the question, "How would you organize your data in a way that creates or does not create a visible difference between graphical representations?" Only one of the groups working on the amounts of calories in foods made a comment on the situations creating or not creating a difference on the chart they drew. The group made the following comment on this subject: "*To show that there is no difference, we would separate cereals, meat, etc. and draw a separate chart for each food group*." With this statement, the students emphasized that the groups containing food with similar calories should be represented in different charts and stated that difference between the amounts of calories could decrease. In this way, they made a proper comment. They expressed what should be done to make more difference visible in the chart as follows: "*We would put salty food on one side and fruits and vegetables on the other side. We would also use the food with the highest and the lowest calorie values. By this means, a big difference would appear.*" Most of the tables and charts drawn by the groups did not precisely represent the main ideas provided in the texts. As a result, the explanations made by the groups focused on a single variable. The groups just indicated the numeric values to which the variables corresponded.

Results Concerning the Stage of Interpreting Data

At this stage, the students were requested to make inferences, make comments, and present the most important results based on data analyses. However, to the contrary of what was aimed, they either presented some general information about the subjects they worked on or did nothing at this stage. The students ignored this stage, which was quite significant for both themselves and others to understand what their analyses meant. Two groups put forward certain results and made comments based on the tables and charts they created: the group working on export and one of the groups working on the amounts of calories in foods. Some results and comments provided by the group working on the amounts of calories in foods are as follows: "*The food with the biggest amount of calories is biscuit among cereals, butter among oils, salami among meat products, kashar cheese among milk and egg products, salmon among sea food… the most interesting result for us is that biscuit which we eat frequently has 470 calories.*" The group working on export put forward results indicating the years witnessing the biggest and the smallest amounts of exports. Although they did not collect and analyze data showing the variation of export values by country, they provided the following result to demonstrate the country to which Turkey exports most: "*Germany is the country to which Turkey exports most.*" Even though the students were expected to make sense of and get aware of what they did at this stage, they did not show enough interest in it.

The students were requested to write reflection papers in order to see the experiences and the difficulties they underwent in the statistical process in more detail. What they wrote in their reflection papers indicates that they mostly had difficulty at the stage of posing a problem and formulating hypotheses. A student from the group working on newborn babies stated the difficulty she experienced in posing a problem and the reason for such difficulty as follows: "*I had some difficulty in posing a problem. This is because; in the beginning, our knowledge of babies was limited to only what we saw around us.*" A student from the group working on export stated the difficulty they had in formulating hypotheses told, "*While we were formulating hypotheses, some of us had different ideas. Some hypotheses proved to be right when we collected the data.*" With this statement, he attributed the difficulty experienced in formulating hypotheses to that it came before data collection. While some groups stated that they had difficulty at the stage of collecting data, a student from a group working on the amounts of calories in foods said, "*It was an instructive and informative activity. I had limited knowledge of calorie. We learned more as we searched on our own.*" thereby highlighting that collecting the data at first hand was influential on her learning. The students generally stated that they were more interested in the stage of analyzing data. However, the group working on the transportation choices of the tourists coming to Turkey told that they had the biggest difficulty in creating a chart. The reflection papers of the students also contained what they learned in the statistical process. Some students said that the process helped them have more detailed knowledge of the context. In this sense, a student from one of the groups working on the amounts of calories in foods said, "The *process answered the questions about calorie which I can face in my life. I learned that calorie is an important problem for our lives and we should take care of our health.*" In their reflection papers, some students also stated that they learned to formulate a hypothesis. One of the students wrote, "*We didn't know how to formulate a hypothesis. I learned that it refers to detecting problems concerning a particular issue and producing solutions to them.*" Some students denoted that they acquired new knowledge on the subjects they worked on and corrected what they knew wrongly in the process. The students were of the same opinion that the process was amusing and informative overall.

Discussion, Conclusion and Suggestions

This study aimed to depict the experiences and the difficulties undergone by the students in the statistical process as well as their views concerning the process. The research results are given in this section based on the statistical process stages.

At the stage of specifying a problem, each group was able to pose a problem in accordance with the context given in the relevant activity. However, the groups posed problems that did not require obtaining statistical results, but that could be answered differently by different people (i.e. problems with no definite answers). That is consistent with the result of Pfannkuch and Wild (2004) reporting that in searching problems concerning a given context, students ignore data and just make use of their own beliefs. In other words, the students posed problems that represented the contexts given in the activities and could be directly answered by the help of the texts rather than the problems that could be answered though data analysis. Thus, it can be said that the behaviors displayed by the students at the stage of posing a problem were included in the lowest level of the solo taxonomy (i.e. answering based on one's own thoughts or beliefs rather than providing the requested information). This may be because; the students had imperfect knowledge of the contexts given or failed to establish a relationship with the contexts given. However, knowledge of context and establishing relationship between data and context are among the key elements of statistical literacy (Watson, 2006; Koparan, 2012). The difficulty experienced by the students at this stage may also result from that they had not had any experience in posing a problem before. According to Kojima and Miwa (2008), the fact that people pose different problems plays an important role in increased different and more flexible thoughts. They also report that the problems posed by students are mostly similar and lack of diversity. To Akay (2006), students need to pose new problems by adjusting the given situations and the existing problems. As posing a problem is so important, it is nonsense to present problems involving only numerical solutions to students. Therefore, it is recommended to include activities involving posing problems based on contexts in learning environments rather than the problems of this sort. After the stage of posing a problem, the students were expected to formulate hypotheses for the questions posed based on the contexts provided in the activities. The students did not have much difficulty in formulating hypotheses based on the questions. However, they did not specify their reasons for formulating such hypotheses and did not make any explanation about what they grounded their hypotheses on. NCTM (2000) emphasizes that students from all stages from kindergarten to the end of secondary education should be provided with opportunities to formulate mathematical hypotheses and to investigate the correctness of such hypotheses. This is because; formulating hypotheses is part of teaching associated with mathematical reasoning. The difficulty experienced by the students in the present study may be because these kinds of opportunities are not provided to them. Frerking (1994) says that formulating hypotheses is an important method improving mathematics and allows mathematical communication, thereby highlighting the importance of formulating hypotheses. For that reason, enabling students to formulate hypotheses in learning environments may contribute to the complete achievement of teaching.

The students were more successful at the stage of collecting data. However, the intended success was not showed at this stage, which was considered to be the easiest stage in the beginning. The groups were asked to obtain data concerning the contexts provided via the Internet. However, the students collected data providing limited knowledge by focusing on just one aspect of the context. This may be because; they had not conducted any research of this sort before, and they collected data based on their creativity without setting bounds to the research subjects. Normally, students are provided with data and are requested to make inferences out of such data. In the present study, however, attention was focused on the students' collecting their own data and producing answers based on their creativity. In

the meanwhile, it is important that actual data that involve different dimensions are used for students to generate more creative solutions. Therefore, it is recommended that projects assigned to students request them to collect data appropriate to relevant contexts rather than providing them with ready data, thereby making them more active in the process.

The groups that collected data based on the texts given were expected to present their data by using appropriate representations and explain them together with their reasons (i.e. being engaged in the data analysis stage). The groups made efforts to represent their data. Although the data related to the activities provided to the students contained features belonging to more than one variable, the groups formed their tables and charts by focusing on only one feature or variable. Even though the students were of the same opinion that the charts and the tables formed by them did not precisely represent the data related to the activities, they failed in separate representations. This may be because; the students had created charts by considering just one feature until then, or they had been requested to make interpretations and inferences out of ready tables and charts. The student groups failed to draw comprehensive charts representing the data appropriately and had difficulty in presenting the data related to more than one variable simultaneously. This may be why the students drew simple charts. Though the students formed simple charts, they mostly failed to use different types of charts for their intended purposes. The students took the data as ordered pairs and represented them in the coordinate system by demonstrating ordered pairs. However, the students were not able to take sufficient advantage of the charts that allow data comparison and enable to make verbal inferences (Temiz & Tan, 2009). The students' lack of knowledge of charts and their types may have been influential on that. The students stated that although they wanted to compare the data, they had difficulty in it and were not able to do comprehensive drawing because the data were complicated. This result is consistent with that of other studies conducted on students from different grades reporting that students have difficulty in creating charts (Padilla, McKenzie & Shaw, 1986; Clement 1989; Leinhardt, Zaslavsky & Stein, 1990; Brasell & Rowe, 1993; Özgün-Koca, 2008). As the representation of data is important for statistics education (NCTM, 2000; GAISE, 2005; Carmichael, Callingham, Hay & Watson, 2010), it is recommended that activities prepared by considering the difficulties experienced by students in representing data be included in learning environments. In the present study, the students deemed charts fixed and invariable. Thus, they were no able to answer the questions requiring making adjustments on the charts. Teaching students without using questions requiring different interpretations and points of view may have been influential on that. It should be made sure that students undergo experiences where they need to scale their charts in different ways. Moreover, it is thought that if similar teaching processes are designed, students may give appropriate responses in similar situations. Accordingly, it is recommended that activities containing various arrangements concerning data representation be designed so that conceptual understanding occurs, and students make inferences from charts.

Finally, the groups were expected to make inferences from the data and make comments on the process. In this regard, they were requested to interpret the results they obtained and state the experiences and difficulties they underwent during group works. The students made general comments and explained the results they obtained by generalizing them. The students were not able to make sufficient inferences from the data, though it is considered quite important (Gal, 2002; Watson & Callingham, 2003). The interpretations of the students were very superficial. Although the groups did not provide sufficient explanations about what they did, they made correct comments on their shortcomings and wrong answers. This may be because; the students had not gone through such a statistical process until then. It is important that students give correct answers and make appropriate comments, but it is also important that they think on their mistakes and wrong thoughts and notice

their mistakes. The students at least had a critical approach to their own works. As making effective comments and verbal inferences from data requires experience, it is recommended that activities be prepared in such a way that improves these skills. The students were asked to summarize the statistical process in order to determine better the difficulties undergone by them in the statistical process and the stages in which they were interested. The students stated they experienced various difficulties in the process even though they enjoyed the process overall. The groups had the biggest difficulty at the stage of posing a problem. The unfamiliarity of the students with the subjects in the activities may have been influential on that. The students stated they enjoyed most while they were drawing tables and charts. The students mostly stated that they were satisfied with the statistical process, and this process enabled them to correct their wrong knowledge and acquire new knowledge. Although the students had difficulties at some points and were not familiar with such activities, real life activities were seen to have a positive influence on them. Thus, it is recommended that these kinds of arrangements be made in teaching at certain intervals, and the active participation of students be ensured.

The present study is significant because it allowed the students to pose problems and formulate hypotheses about real life situations, work both in group and individually, and collect data on their own by choosing their own resources. The groups who collected their data were set free to present the answers they obtained in regard to the problems to their classmates. Even though the groups represented their data from their own perspectives, the appropriateness of such data representations and whether or not they provided answers to the problems were opened up for discussion, thereby providing the students with an opportunity to revise their representations. In this way, the students got involved in a platform for discussions where they could both evaluate their own works and give shape to other works. This platform for discussion helped the students to check the appropriateness of their data representations, make self-evaluations, and see different ways of analyzing their data by handling them as a whole. Such an environment enables students to give up getting and using knowledge without any effort and giving answers based on operational knowledge and to start to specify their problems on their own, seek solutions, manage to find relevant results, and develop a critical perspective. That may help students develop different perspectives. In this sense, it is recommended that teachers who play an important role in the design of learning environments make students go through experiences similar to those described above.

The failure of the students in data representations implies that this issue should be handled in a more detailed way. Therefore, it is recommended that researchers make students get aware of different data representations through some training and examine their influences. A similar study may be carried out with students from higher grades by adapting the subjects to them.

The students had a narrow framework in data representation. This may be because of the limitedness of the contexts related to real life situations provided for the students to search. In addition, the students may have been unfamiliar with the contexts given to them because the research subjects were distributed to the students randomly. More comprehensive results may be obtained by giving the same context to more than one group, thereby creating a more effective platform for discussion.

At the stage of posing a problem and formulating hypotheses, the students posed problems whose answers may vary from person to person rather than problems in trying to answer which statistical results can be obtained. That shows that the 6th grade mathematics curriculum acquisition, "*Posing problems for research in regard to a situation given*" was not achieved. This may be because; students are not provided with experiences where they can pose problems based on specific contexts in learning environments. The students were seen to be more successful at the stage of collecting data in comparison to the stage of specifying a problem and formulating hypotheses. In today's world, even very young individuals can keep up with technological advancements. In this sense, familiarity with technology enables the students to reach data related to the problems they posed via the Internet. Thus, giving students opportunities to pose different problems by providing them with contexts similar to their daily lives in learning environments may yield meaningful results. Apart from that, it is important that students go through experiences where they can see the ways of collecting data in accordance with their problems. By this means, students take part in research process. At the stage of analyzing data, the students had difficulty in creating appropriate representations that summarized their data. The 6th, 7th, and 8th grade mathematics curricula include acquisitions concerning drawing different types of charts. In handling these acquisitions in learning environments, different types of charts are taught, and students are provided with knowledge of where to use different types of charts including column charts, line charts, etc. However, students are not engaged in practices where they can use these types of charts to summarize data, or they draw charts based on just one variable. That may have caused the students to fail at the stage of analyzing data. If a research process based on contexts close to daily life is offered to students, students may gain experience in statistical process at first hand, and the difficulties they may experience in the process may be eliminated.

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